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RESPONSES OF BIRD COMMUNITIES TO EARLY SUCCESSIONAL HABITAT IN A MANAGED LANDSCAPE

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ABSTRACT.—I examined short and long term responses of breeding bird communities to the systematic creation of early successional habitat resulting from forest management at a 1,120-ha study site in the Ridge and Valley Province of Pennsylvania, from 1998 through 2002. Species richness and abundances of all species combined and of early successional species increased from precut (1998–1999) to postcut eras (2001–2002) in a treated sector (aspen, *Populus* spp., and mixed oak, *Quercus* spp., areas combined), an uncut control sector, and the total study site (treated and control sectors combined) after the fourth cutting cycle. Abundances of a woodland species (Red-eyed Vireo, *Vireo olivaceus*) and four early successional species (e.g., Field Sparrow, *Spizella pusilla*) also increased. Over the past 15 years, which spans the third and the fourth cutting cycles at the study site, three woodland species increased significantly in both treated and control sectors (Red-eyed Vireo) or in the treated sector only (Ovenbird, *Seiurus aurocapillus*, and American Redstart, *Setophaga ruticilla*). The population of an early successional species (Indigo Bunting, *Passerina cyanea*) increased significantly in both treated and control sectors. Population trends of three woodland and three early successional species at the study site paralleled statewide or provincial increases in these species over the past two decades. My study has shown that the management of early successional habitats in extensively forested areas will be of benefit for the long term conservation of both early successional and mature forest bird species within a forested landscape. *Received 10 February 2003, accepted 29 June 2003.*

Long term studies focusing on wildlife responses to forest management are relatively scarce, yet are crucial to an understanding of regional trends in populations (Gullion 1990, Yahner 2000). In the northeastern United States, forest maturation and farm abandonment likely are responsible for population declines of a variety of wildlife dependent upon early successional habitat (Litviatis 1993, Brawn et al. 2001, Trani et al. 2001). Thus, an important question is whether habitat can be created for conservation of both early successional and mature forest species within the same managed forested landscape.

The Barrens Grouse Habitat Management Area (GHMA) was established in 1976 for the systematic creation of habitat for Ruffed Grouse (*Bonasus umbellus*) through even-aged management (Yahner 1993). This was achieved by establishment of 4-ha "activity centers" for adult grouse (Gullion 1977), giving an interspersion of 1-ha contiguous plots of different ages in aspen (*Populus* spp.) and mixed oak (*Quercus* spp.) cover types (Yahner 1993, 1997). Grouse habitat management at the Barrens GHMA has the potential to provide valuable breeding habitat for coexisting bird species dependent upon young forested plots. My objectives were to (1) compare bird community structure and composition immediately before and after a fourth cutting cycle at the Barrens GHMA and (2) examine trends in populations of individual species (in particular, early successional species dependent upon stands <3 years since cutting) in response to creation of additional early successional habitat resulting from the fourth cutting cycle. I compared these results to those obtained at the Barrens GHMA immediately after the third cutting cycle (Yahner 1993) and to those obtained 5–8 years after the third cutting cycle (Yahner 1997).

METHODS

I conducted my study at the 1,120-ha Barrens Grouse Habitat Management Area (GHMA; 40° 47′ N, 78° 58′ W) on State Game Lands 176, Centre County, in the Ridge and Valley Province of Pennsylvania (Yahner 1993, 1997). The Barrens GHMA was divided into an uncut control sector and a treated sector of approximately equal size (576 ha and 544 ha, respectively).

The treated sector consisted of 136 contiguous 4-ha blocks; each block was subdivided into 1-ha plots (A–D, each 100 × 100 m) arranged in a clockwise fashion (Yahner 1993, 1997, 2000). Plots A–D in 60 blocks (240 ha,

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aspen area) were cut systematically during four cutting cycles (winters 1976–1977, 1980–1981, 1986–1987, and 1999–2000), whereas plots A–C in 76 blocks (304 ha, mixed oak area) were cut during three cutting cycles (winters 1976–1977, 1986–1987, 1999–2000). Subsequent to the initial three cutting cycles, 75% of the plots in the aspen area and 50% of the plots in the mixed oak area were cut; but after the fourth cutting cycle (1999–2000), all plots in the aspen area were cut and 75% of the plots in the mixed oak area were cut. In plots cut during the third and fourth cutting cycles (plots C and D in the aspen area, plots B and C in the mixed oak area), 15–20 overstory trees per plot were retained.

Major overstory trees (woody stem >7.5 cm dbh, >1.5-m tall) in uncut habitat (control sector and plot D in the mixed oak area) were white oak (*Quercus alba*), chestnut oak (*Q. montana*), northern red oak (*Q. rubra*), scarlet oak (*Q. coccinea*), red maple (*Acer rubrum*), bigtooth aspen (*Populus grandidenta*), quaking aspen (*P. tremuloides*), and pitch pine (*Pinus rigida*; Yahner 1993, 1997). Overstory trees were about 80–90 years old. Principal understory woody species included oak, red maple, aspen, and black cherry (*Prunus serotina*).

I selected 90 representative 1-ha plots for bird sampling, with 10 plots in the control sector and 80 plots in aspen and mixed oak areas (10 each of plots A–D per area). These were the same 90 plots used during previous studies at the Barrens GHMA (plot selection and avian sampling protocols follow Yahner 1993, 1997). Plots selected were separated by >200 m, and centers of plots were >50 m from disturbances (e.g., logging roads) to reduce edge effects (Strelke and Dickson 1980, Yahner 1987).

I visited each plot once per year in late May to early June in 1998 and 1999 immediately prior to the fourth cutting cycle (precut era) and in late May to early June in 2001 and 2002 (postcut era). The randomized order of visits and number of visits per plot were identical to those of previous studies (Yahner 1993, 1997). After a 1-min equilibrium period, I counted all birds seen or heard within 30 m of each plot center, using a 5-min point count; counts were made between sunrise and 09:00 EST. A 30-m radius positioned in the plot center minimized edge effects at the interfaces between plots of different age in the treated sector (Repenning and Labisky 1985). Birds flying over a plot were not counted, and movements of individual birds were monitored carefully to minimize counting the same bird twice.

I calculated species richness and total abundance for each of the three areas (aspen area, mixed oak area, and control sector) during precut and postcut eras (after Yahner 1993, 1997). Species richness was the total number of species, and total abundance was the number of contacts/100 ha of all species combined. In addition, I calculated abundances of individual species for each area during both eras.

To compare short term responses of bird populations at Barrens GHMA to creation of additional early successional habitat, I compared observed to expected numbers of contacts for all species combined, for early successional species combined, and for individual species with adequate sample sizes (>10 contacts combined) between eras in each area separately and for the total study site with χ^2 goodness-of-fit tests (Sokal and Rohlf 1995). I calculated expected number of contacts per era as the total number of contacts observed in both eras combined divided by 2.

I also contrasted observed and expected numbers of contacts of individual bird species between precut and postcut eras in plots cut during the fourth cycle (plot D in the aspen area and plot C in mixed oak area) using χ^2 goodness-of-fit tests; expected numbers of contacts were calculated as the total number observed in these two plot types during both eras combined divided by 2.

To compare long term trends in bird populations at the Barrens GHMA, I examined abundances of individual species immediately subsequent to the third cutting cycle during three breeding seasons (1987–1989; Yahner 1993), during three breeding seasons approximately midway between third and fourth cutting cycle (1993–1995; Yahner 1997), and during two breeding seasons immediately after the fourth cutting cycle (2001–2002; present study). I compared observed to expected numbers of contacts for species with adequate sample sizes (>15 contacts/area) among the

TABLE 1. The abundance (contacts/100 ha) of species varied among areas and between precut and postcut eras at the Barrens Grouse Habitat Management Area, Pennsylvania. In the precut era, 75% of the aspen area and 50% of the mixed oak area were cut in 1998–1999. Actual numbers of contacts are in parentheses. Only common (≥10 contacts) species are shown, but contacts of uncommon species are included in values of species richness and total abundance.[a]

	Precut era (1998–1999)			
	Aspen	Mixed oak	Control	Total site
Ruffed Grouse, *Bonasa umbellus*	4 (1)	13 (3)	18 (1)	10 (5)
Great Crested Flycatcher, *Myiarchus crinitus*	4 (1)	13 (3)	35 (2)	12 (6)
Eastern Wood-Pewee, *Contopus virens*	0 (0)	13 (3)	53 (3)	12 (6)
Blue Jay, *Cyanocitta cristata*	22 (5)	18 (4)	18 (1)	20 (10)
Tufted Titmouse, *Baeolophus bicolor*	4 (1)	31 (7)	0 (0)	16 (8)
Black-capped Chickadee, *Poecile atricapillus*	31 (7)	4 (1)	0 (0)	16 (8)
Blue-gray Gnatcatcher, *Polioptila caerulea*	0 (0)	9 (2)	0 (0)	4 (2)
Wood Thrush, *Hylocichla mustelina*	4 (1)	13 (3)	0 (0)	8 (4)
Gray Catbird, *Dumetella carolinensis*	70 (16)	31 (7)	0 (0)	46 (23)
Cedar Waxwing, *Bombycilla cedrorum*	0 (0)	13 (3)	35 (2)	10 (5)
Red-eyed Vireo, *Vireo olivaceus*	62 (14)[c]	92 (23)	248 (14)	102 (51)[c]
Golden-winged Warbler, *Vermivora chrysoptera*[b]	9 (2)	0 (0)	0 (0)	4 (2)
Black-and-white Warbler, *Mniotilta varia*	35 (8)	13 (3)	0 (0)	22 (11)
Chestnut-sided Warbler, *Dendroica pensylvanica*[b]	22 (5)	22 (5)	0 (0)	20 (10)
Ovenbird, *Seiurus aurocapillus*	207 (47)	70 (16)	142 (8)	142 (71)
Common Yellowthroat, *Geothlypis trichas*[b]	31 (7)	35 (8)	0 (0)	30 (15)[c]
American Redstart, *Setophaga ruticilla*	35 (4)	106 (24)	106 (6)	68 (34)
Rose-breasted Grosbeak, *Pheucticus ludovicianus*	22 (5)	26 (6)	0 (0)	22 (11)
Northern Cardinal, *Cardinalis cardinalis*	0 (0)	4 (1)	0 (0)	2 (1)
Indigo Bunting, *Passerina cyanea*[b]	0 (0)	0 (0)	0 (0)	0 (0)[c]
Eastern Towhee, *Pipilo erythrophthalmus*[b]	92 (21)	35 (8)	0 (0)	58 (29)
Field Sparrow, *Spizella pusilla*[b]	4 (1)[c]	0 (0)	0 (0)	2 (1)[c]
Chipping Sparrow, *Spizella passerina*[b]	4 (1)	4 (1)	0 (0)	4 (2)
Brown-headed Cowbird, *Molothrus ater*	4 (1)	22 (5)	17 (1)	14 (7)
Scarlet Tanager, *Piranga olivacea*	18 (4)	31 (7)	106 (6)	34 (17)
Species richness, all species combined	25	31	14	34
Species richness, early successional species	7	4	0	6
Total abundance, all species combined	695 (158)[c]	559 (127)[c]	832 (48)	726 (363)[c]
Total abundance, early successional species	163 (37)[c]	97 (22)[c]	0 (0)	118 (59)[c]

[a] Including Northern Flicker (*Colaptes auratus*; two in aspen area and one in mixed oak area) and Yellow-breasted Chat (*Icteria virens*; one in aspen area); both species in postcut era.

[b] Early successional species adapted to young (≤3 years since cutting) forested plots.

[c] Observed and expected number of contacts differed significantly between eras (see text for *P* values).

three time periods in treated and control sectors separately using χ^2 goodness-of-fit tests. I calculated expected numbers of contacts as the total number of contacts observed in all three time periods combined for a given sector divided by 3 or 2 (depending upon the period length). If abundances were significantly different among time periods in a given sector, I used *a posteriori* χ^2 goodness-of-fit tests about the time period of interest.

RESULTS

Species richness of all species and of early successional species increased from precut to postcut eras throughout the Barrens GHMA (Table 1). Furthermore, abundances of all species combined and of early successional species increased significantly between eras in the aspen area (both $P < 0.0001$), the mixed oak area ($P = 0.0005$ and $P = 0.003$, respectively), and the total site (both $P < 0.0001$). Abundance of a woodland species, the Red-eyed Vireo (*Vireo olivaceus*), also increased significantly between eras in the aspen area ($P = 0.012$) and total site ($P = 0.005$). Similarly, abundances of four early successional species increased from precut to postcut eras in the total site (Common Yellowthroat, *Geothlypis trichas*, $P = 0.037$; Indigo Bunting, *Passerina cyanea*, $P < 0.0001$; Field Sparrow, *Spizella*

TABLE 1. EXTENDED.

Postcut era (2001–2002)			
Aspen	Mixed oak	Control	Total site
18 (4)	4 (1)	36 (2)	14 (7)
9 (2)	18 (4)	53 (3)	18 (9)
0 (0)	22 (5)	36 (2)	14 (7)
13 (3)	26 (6)	71 (4)	26 (13)
0 (0)	4 (1)	71 (4)	10 (5)
26 (6)	13 (3)	18 (1)	20 (10)
9 (2)	18 (4)	53 (3)	18 (9)
18 (4)	26 (6)	0 (0)	20 (10)
40 (9)	40 (9)	0 (0)	36 (18)
22 (5)	0 (0)	0 (0)	10 (5)
136 (31)	141 (32)	342 (19)	164 (82)
13 (3)	0 (0)	0 (0)	6 (3)
31 (7)	0 (0)	0 (0)	14 (7)
44 (10)	26 (6)	0 (0)	32 (16)
180 (41)	79 (18)	54 (3)	124 (62)
62 (14)	66 (15)	0 (0)	58 (29)
35 (8)	92 (21)	71 (4)	66 (33)
35 (8)	35 (8)	18 (1)	34 (17)
22 (5)	9 (2)	18 (1)	16 (8)
53 (12)	35 (8)	0 (0)	40 (20)
114 (26)	48 (11)	18 (1)	76 (38)
53 (12)	13 (3)	0 (0)	30 (15)
31 (7)	13 (3)	0 (0)	20 (10)
9 (2)	9 (2)	54 (3)	14 (7)
18 (4)	35 (8)	54 (3)	30 (15)
33	30	18	40
9	7	1	9
1,056 (240)	823 (187)	1,062 (60)	974 (487)
383 (87)	207 (47)	18 (1)	270 (135)

pusilla, $P = 0.0006$; and Chipping Sparrow, *Spizella passerina*, $P = 0.020$).

I observed significant declines in use of cut plots in both aspen and mixed oak areas (plots D and C, respectively) of the Barrens GHMA by three woodland species (Red-eyed Vireo, $P = 0.018$; American Redstart, *Setophaga ruticilla*, $P = 0.020$; and Ovenbird, *Seiurus aurocapillus*, $P = 0.043$) immediately after the fourth cutting cycle (Table 2). In contrast, after conversion of these uncut plots to early successional plots, I noted significant and immediate increases in use of these plots by three early successional species (Indigo Bunting, $P < 0.0001$; Eastern Towhee, *Pipilo erythrophthalmus*, $P = 0.004$; and Field Sparrow, $P < 0.0001$).

Over the past 15 years, which spans the third and the fourth cutting cycles at the Barrens GHMA, three woodland species increased significantly in both treated and control sectors (Red-eyed Vireo, $P < 0.0001$ and $P = 0.001$, respectively) or in the treated area only (Ovenbird, $P < 0.0001$; American Redstart, $P < 0.0001$; Table 3). I noted that one early successional species, the Indigo Bunting, increased significantly in the treated sector ($P = 0.015$). The Baltimore Oriole (*Icterus galbula*) was the only species that declined significantly in the treated sector over this time period ($P = 0.028$).

DISCUSSION

My study has shown that species richness and abundances of all species combined and of early successional species increased from

TABLE 2. Some species increased while others decreased between the precut (1998–1999) and postcut (2001–2002) eras in uncut aspen D and oak C plots (see text) combined in the Barrens Grouse Habitat Management Area, Pennsylvania. Only species with ≥5 observations in these plots in both eras combined are shown.

	Contacts		Change (%)
	Precut	Postcut	
Red-eyed Vireo[a]	43	8	−35
Chestnut-sided Warbler	0	56	+56
Ovenbird[a]	35	0	−35
Common Yellowthroat[a]	0	71	+71
American Redstart[a]	36	7	−29
Rose-breasted Grosbeak	18	19	+1
Indigo Bunting[a]	0	100	+100
Eastern Towhee[a]	7	38	+31
Field Sparrow[a]	0	94	+94
Chipping Sparrow	50	67	+17
Scarlet Tanager	73	50	−32

[a] Observed and expected number of contacts differed significantly between precut and postcut eras (see text for *P* values).

precut to postcut eras in part because of greater habitat diversity created by the fourth cutting cycle at the Barrens GHMA. For example, only 30% of the Barrens GHMA was subject to even-aged management immediately after the third cutting cycle (plots of 4 different age classes = 3 different-aged cut plots + uncut plots) compared to 42% of the total area managed in the postcut era (plots of 5 different age classes = 4 different-aged cut plots + uncut plots; Yahner 1997). Moreover, immediately subsequent to the fourth cutting cycle, 12% of the Barrens GHMA was in young, early successional habitat (<3 years since cutting). Thus, a mosaic of forested plots of various ages after the fourth cutting cycle provided suitable habitat for a variety of bird species in a localized area (Yahner 1993, 1997, 2000).

Early successional habitat, such as that created at the Barrens GHMA, has regional and statewide significance to conservation of early successional bird species because forests in Pennsylvania have matured with reduced timber harvest and farm abandonment (Powell and Considine 1982, McWilliams et al. 2002). The significant increase in use of young (<3 years since cutting) forested plots immediately subsequent to the fourth cutting cycle at the Barrens GHMA by Indigo Bunting, Eastern Towhee, and Field Sparrow attests to the value of creating early successional habitats for the benefit of these species (Brawn et al. 2001). Indigo Buntings, in particular, were present in

TABLE 3. Abundance (contacts/100 ha) of some species varied among time periods at the Barrens Grouse Habitat Management Area, Pennsylvania. Only species with ≥15 contacts in a given sector are shown.

	Treated sector			Control sector		
	1987–1989	1993–1995	2001–2002	1987–1989	1993–1995	2001–2002
Blue Jay	21	27	20	0	0	71
Black-capped Chickadee	23	25	20	58	24	18
Wood Thrush	30	18	22	23	0	0
Gray Catbird	81	89	40	0	0	0
Red-eyed Vireo[a]	32[b]	52	139[c]	128[b]	177	336[c]
Golden-winged Warbler	35	35	8	0	0	0
Black-and-white Warbler	16	40	16	12	0	0
Chestnut-sided Warbler	42	56	35	0	0	0
Ovenbird[a]	48[b]	140	131	128	177	54
Common Yellowthroat	128	93	64	0	0	0
American Redstart[a]	0[b]	51	64[c]	0	24	71
Rose-breasted Grosbeak	30	49	35	0	47	18
Indigo Bunting[a]	30	9[b]	44[c]	0	0	0
Eastern Towhee	99	119	81	0	0	18
Field Sparrow	48	30	33	0	0	0
Brown-headed Cowbird	11	30	8	47	59	54
Baltimore Oriole[a]	32[c]	21	0[b]	12	0	0
Scarlet Tanager	27	30	27	71	12	54

[a] Observed and expected number of contacts differed significantly among time periods in a given era (see text for *P* values).
[b] Number of contacts in this time period was significantly lower than in other time periods ($\chi^2 \geq 3.84$, df = 1, $P \leq 0.05$).
[c] Number of contacts in this time period was significantly higher than in other time periods ($\chi^2 \geq 3.84$, df = 1, $P \leq 0.05$).

recently cut plots of the treated sector because of the presence of overstory residual trees, which were used as perch and singing sites, thereby supporting the value of residual trees in cut stands for bird populations (Rodewald and Yahner 2000, Yahner 2000).

I attributed increases in Red-eyed Vireo populations between eras to regional population trends rather than to being a function of forest management at the Barrens GHMA. Based on data obtained from the North American Breeding Bird Survey from 1980–2000, Red-eyed Vireos increased significantly statewide and in the Ridge and Valley Province of Pennsylvania (Sauer et al. 2001). Reduced abundance of Baltimore Oriole populations at the Barrens GHMA paralleled declines in this species noted along Breeding Bird Survey routes in Pennsylvania since the mid-1980s (Robbins et al. 1989).

Two of five early successional species exhibiting population increases from precut to postcut eras (Field Sparrow and Indigo Bunting) at the Barrens GHMA had significant statewide and provincial population declines (Sauer et al. 2001). In addition, populations of a third early successional species (Eastern Towhee) have been reduced significantly in the Ridge and Valley Province. Thus, on a localized basis, the Barrens GHMA provides important breeding habitat to several early successional bird species that are becoming less common on a broader geographic scale (Yahner 1991, 1993, 1997). Similarly, I and others have shown that electric transmission rights-of-way in extensively forested regions of Pennsylvania and elsewhere in the northeastern United States provide important early successional habitat for these same declining bird species (Bramble et al. 1994; King and Byers 2002; Yahner et al. 2002, 2003).

Conservation implications.—Forest management of small, contiguous 1-ha plots to create activity centers for Ruffed Grouse has benefited this species over the past two decades at the Barrens GHMA (McDonald et al. 1994). Intensive forest management on this site also has benefited coexisting early successional songbird species, but these small plots become less suitable as habitat for these species as plant succession progresses (Yahner 1997, Lewis and Yahner 1999). My study has shown, however, that periodic creation of recently cut plots through even-aged management has a positive influence on the breeding bird community, especially early successional species. Furthermore, abundances of woodland species do not appear to be affected detrimentally by intensive management for grouse habitat on a local scale. Although considerable attention has been given to managing extensive forested tracts for woodland bird species, certain tracts of land (e.g., the Barrens GHMA) should be managed specifically as early successional habitats in extensively forested areas (e.g., northcentral Pennsylvania; Askins 2001). This is critical to the conservation of regional populations of early successional bird species, which are among the wildlife experiencing precipitous population declines in recent decades (Brawn et al. 2001). Moreover, this strategy demonstrates that habitat for both early successional and mature forest species can be achieved simultaneously within the same managed forested landscape.

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